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[redacted] translation of an article entitled "On Character of Composition vs Property Curves of Metallurgical Solid Solutions at High Temperatures" by A M Borzdyka which appeared in "Doklady Akademii Nauk SSSR", Vol 65, 1949, No 4, at pages 505-507. This article contains a study of applicability of relationships established for atmospheric temperature between chemical composition and properties of solid solution alloys to conditions prevailing in high temperature service. Alloys studied: Fe-Ni; Fe-Cr-Ni, also Fe-Cr-Mn. Properties studied: Creep strength, hardness, conductivity - Conclusions to be drawn./ [redacted]

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A. M. Borzdyka:

ON THE CHARACTER OF COMPOSITION VS. PROPERTY CURVES OF METALLURGICAL SOLID SOLUTIONS AT HIGH TEMPERATURES.

ILLEGIB

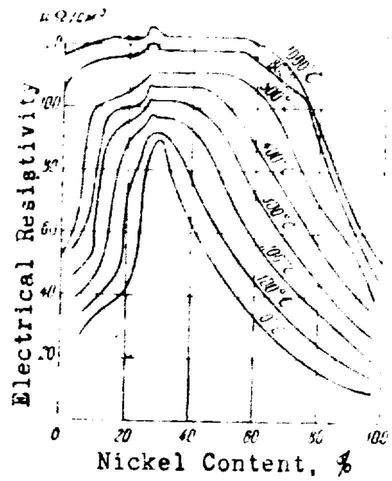

Figure 1. Alloys of Fe-Ni system.

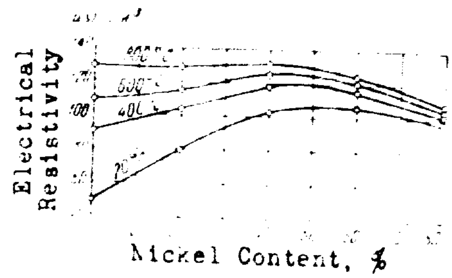

Figure 2. Austenitic alloys of ternary Fe-Cr Ni system (section containing 20% chromium).

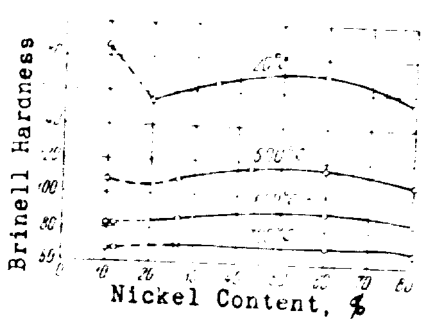

Figure 3. Austenitic alloys of ternary Fe-Cr-Ni system (section containing 20% chromium).

ON CHARACTER OF COMPOSITION VS. PROPERTY CURVES OF METALLURGICAL SOLID SOLUTIONS AT HIGH TEMPERATURES

By A. M. Borzdyka

[Translated from DOKLADY AKADEMII NAUK SSSR, vol. 65, No. 4, pages 505-507, 1949]

S y n o p s i s.

Study of applicability of relationships established for atmospheric temperature between chemical composition and properties of solid solution alloys to conditions prevailing in high temperature service.

Alloys studied: Fe-Ni; Fe-Cr-Ni, also Fe-Cr-Mn. Properties studied: Creep strength, hardness, conductivity.- Conclusions to be drawn.

Practical application of the alloys distinguished by their high strength at elevated temperatures, many of which belong to the class of solid solutions as regards their structure, requires a knowledge of their mechanical and physical properties at the temperatures to which they are exposed in service.

However, systematic study of the properties of metallic solid solutions as a function of their chemical composition has until recently been more or less confined to the range of atmospheric temperatures.

Extrapolation of such values into the range of high temperatures is impossible. Quite apart from the sharp difference between the numerical values of the various properties for ordinary temperature and those for elevated temperatures, the very character of the variation in these properties at high temperatures as a function of the composition may differ profoundly from the relationships established for ordinary temperatures.

Still, the initiator of the composition-property diagrams, N. S. Kurnakov ventured the hypothesis that "by analogy to liquid solutions, increased temperatures are bound to flatten out the isotherms of the properties and displace the minimum point (on the electrical conductivity curve) in the direction of the component having the lower conductivity. Under the same conditions, the maximum of the hardness will be shifted in the direction of the harder component of the alloy." (1)

For a long time, these statements were without confirmation by experiment. To-day, however, it may be regarded as established that increased temperatures diminish the curvature of the composition-property curves and produce a flattening (and sometimes, complete disappearance) of the maximum or minimum point, holding for atmospheric temperature.

To give an example, a set of isotherms of the electrical conductivities (at temperatures ranging from 0 to 1000° C) is presented in Figure 1 for the alloys of the binary system Fe-Ni, which is known to form a structure of uniform γ solid solution. The flattening of the curves with increasing temperature is still more pronounced on the electrical conductivity curves of the alloys of the ternary system Fe-Cr-Ni (cross section for 20% Cr; Fig. 2).

When comparing the curves of Figure 2 with those of Figure 1, the differences in the curvature and the position of the maximum, which latter is absent entirely from the 800° C (1470° F) isotherm, are apparent. This confirms the fact that the properties of ternary systems forming solid solutions do not always vary according to the rules established for binary systems.(3)

It is natural to assume that a flattening of the composition-property curves with increasing temperatures may take place also in the case of the properties characterizing high temperature strength of a metallic alloy, meaning the capacity to retain a sufficient amount of mechanical strength at elevated temperatures.

The results of hardness determinations on alloys of the Fe-Cr-Ni system (20% Cr cross section) at temperatures ranging from 20 to 700° C (68-1290° F) have been plotted in Figure 3 against the nickel content.

The gradual disappearance of the maximum from the curves, as the temperature goes up, is evident. The tests made at a temperature of 700° C (1290° F) give an almost straight line.

The basic property which governs the high temperature strength of a metal or alloy is the creep resistance. As has been shown in an earlier paper by the author[4] the isotherms of the "limiting creep stress", as a function of the nickel content, for the same cross section of the ternary system Fe-Cr-Ni also show a rectilinear character at temperatures of 600 and 700° C (1110 and 1290° F), analogously to the isotherms of Figure 3. A similar picture is offered by the isotherms of creep for the austenitic alloys of the Fe-Cr-Mn system.

All of these facts constitute proof that the classic concept of the variation of the properties of solid solutions as a function of their composition, which is true of atmospheric and moderately high temperatures, does not apply to elevated temperatures.

References:

(1) N. S. Kurnakov, "Introduction to Physical-Chemical Analysis", (Book, in Russian), 1940, p. 121;

(2) T. Yensen, JOURNAL FRANKLIN INSTITUTE, vol. 199, 1925, p. 333;

(3) V. A. Nemilov and T. A. Vidusova, IZVESTIYA SEKTORA PLATINY IONKh AN SSSR, vol. 17, 1940, p. 111;

(4) A. Borzdyka, DOKLADY AKADEM. NAUK SSSR, vol. 63, 1947, No. 3 (sic!).

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